FIG. 1 Prior Art

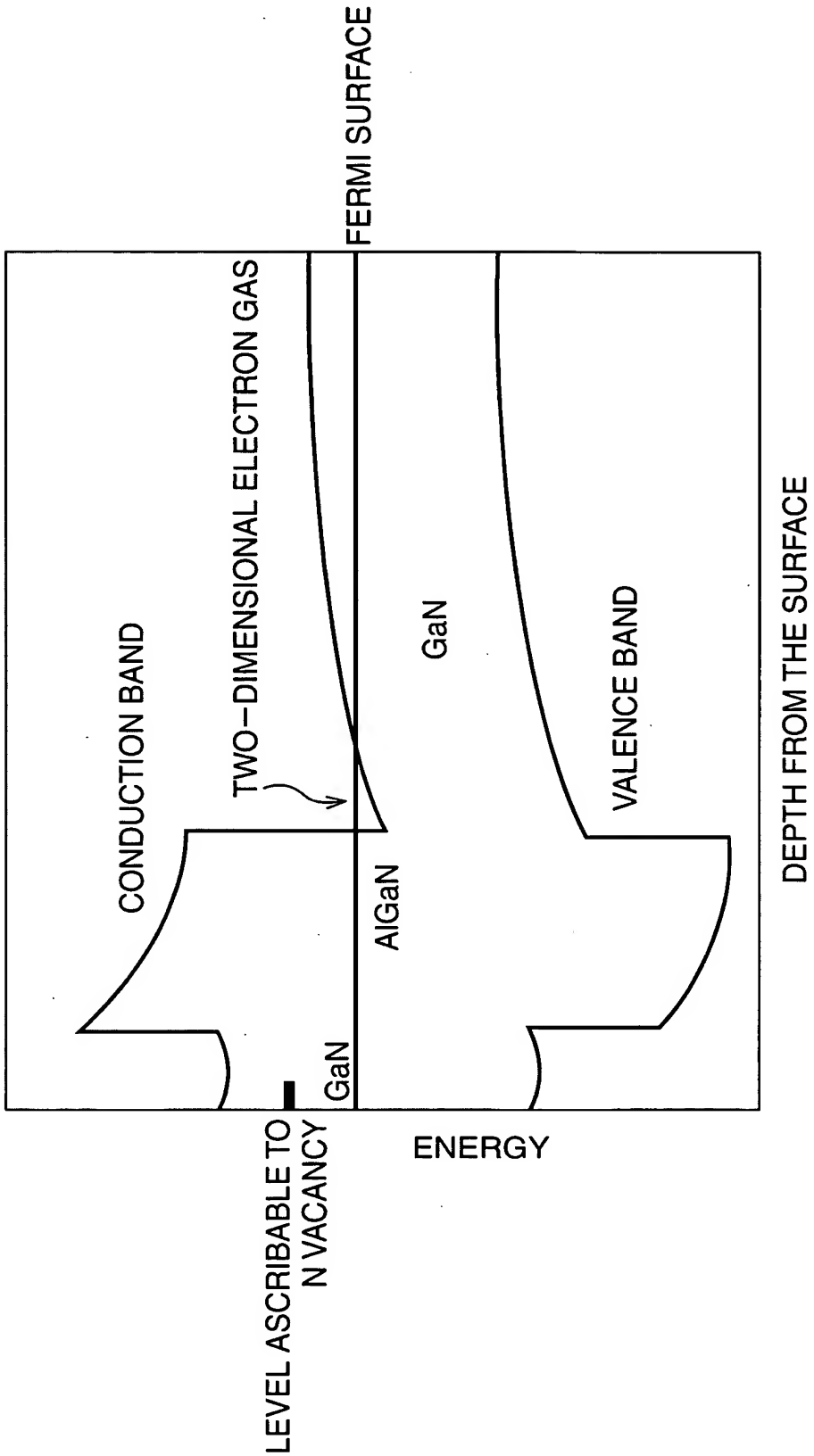


FIG. 2

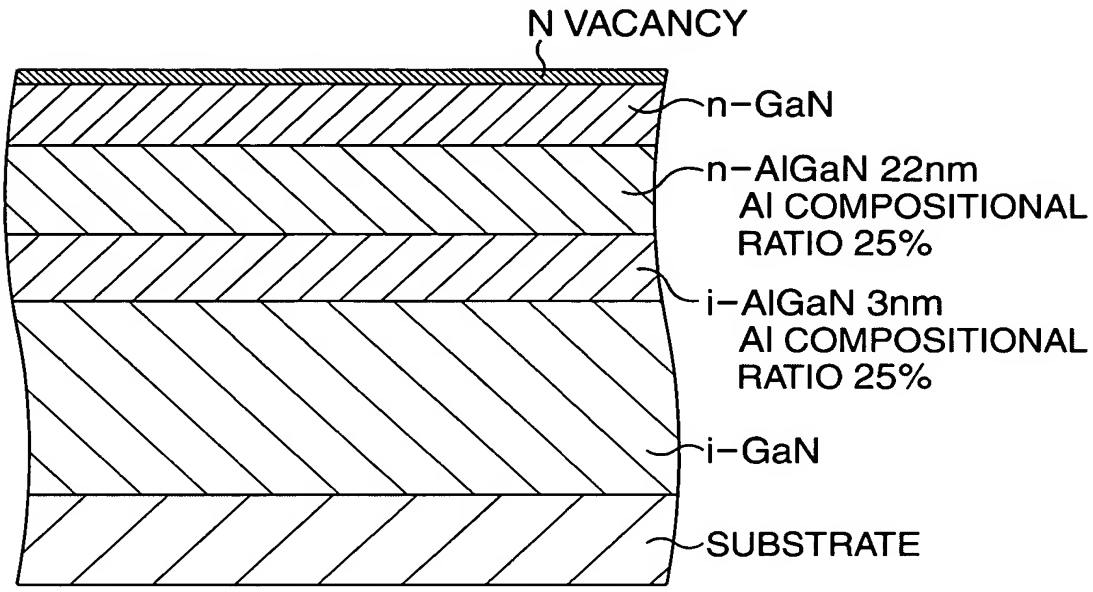

N VACANCY
n-GaN
n-AlGaN 22nm
Al COMPOSITIONAL
RATIO 25%
i-AlGaN 3nm
Al COMPOSITIONAL
RATIO 25%
i-GaN
SUBSTRATE

FIG. 3

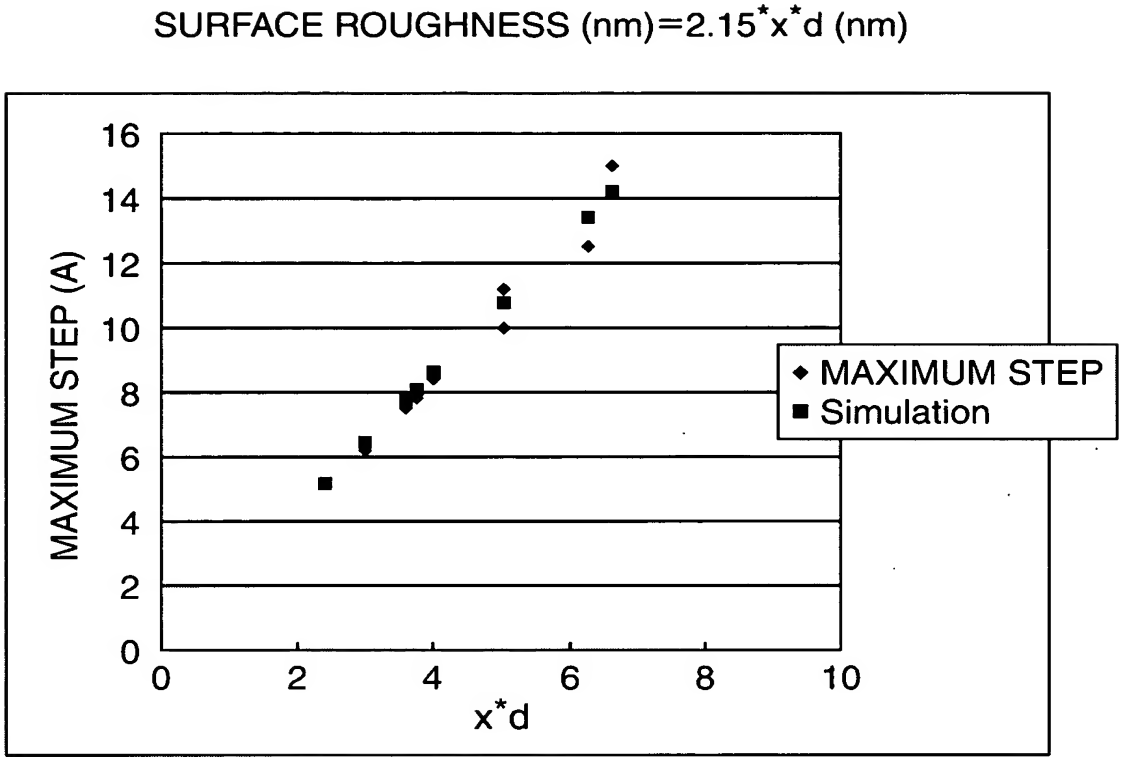

SURFACE ROUGHNESS (nm)=2.15*x*d (nm)
MAXIMUM STEP (A)
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
x*d
MAXIMUM STEP
Simulation

FIG. 4

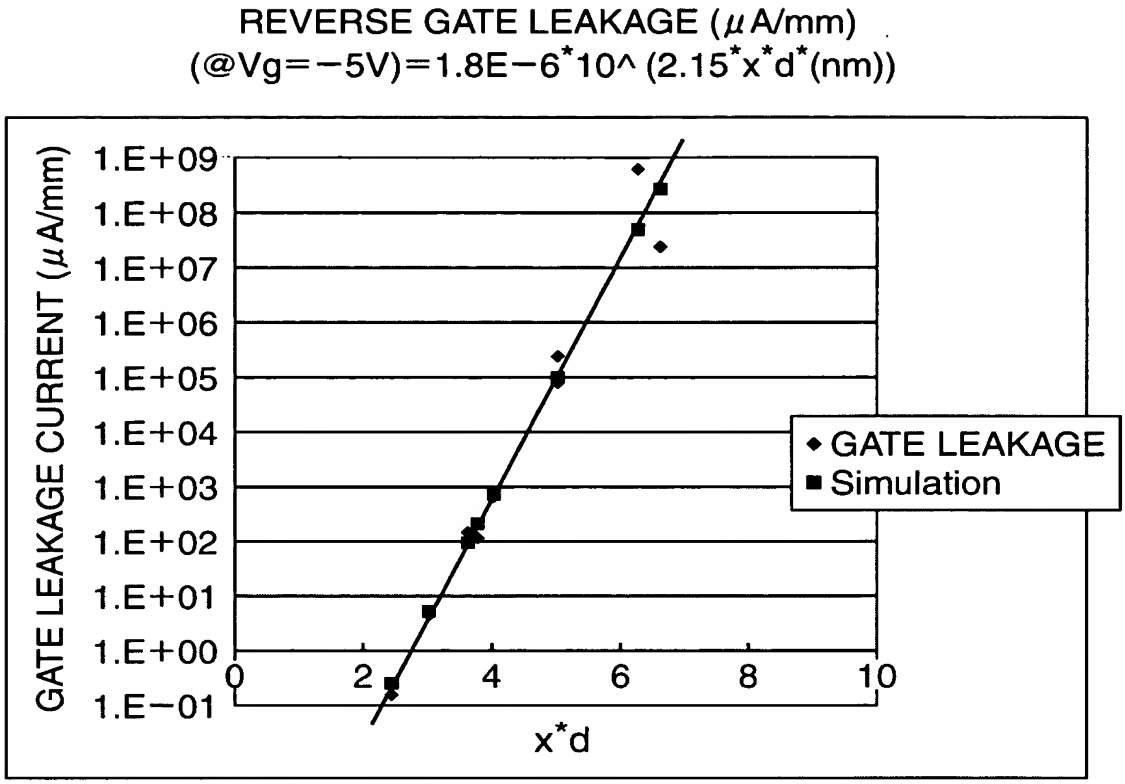

REVERSE GATE LEAKAGE (μA/mm)
(@Vg=−5V)=1.8E−6*10^ (2.15*x*d*(nm))
GATE LEAKAGE CURRENT (μA/mm)
1.E+09
1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E−01
0
2
4
6
8
10
x*d
GATE LEAKAGE
Simulation

FIG. 5

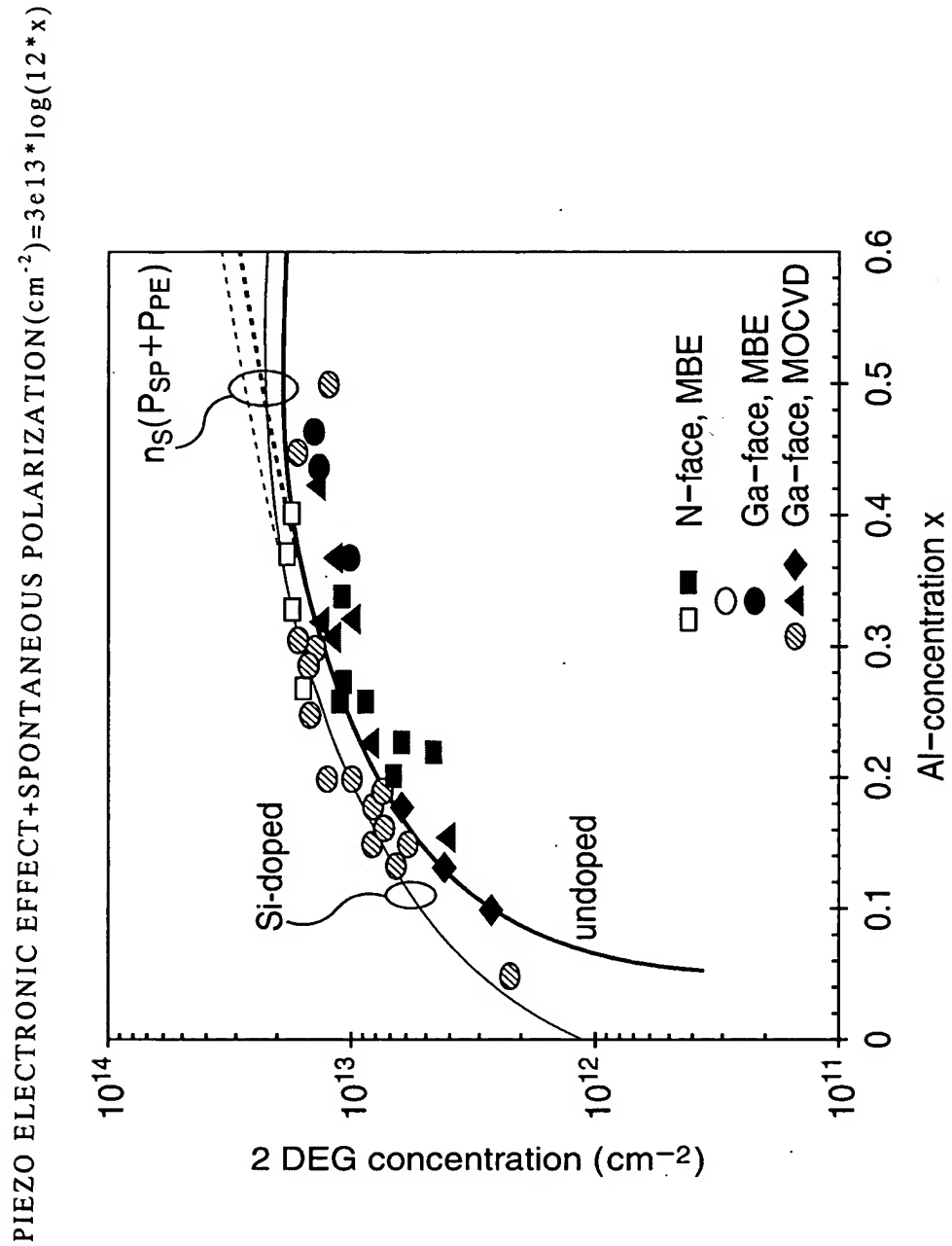

PIEZO ELECTRONIC EFFECT+SPONTANEOUS POLARIZATION(cm^{-2})=3e13*log(12*x)
$n_S(P_{SP}+P_{PE})$
Si-doped
undoped
N-face, MBE
Ga-face, MBE
Ga-face, MOCVD
10^{14}
10^{13}
10^{12}
10^{11}
2 DEG concentration (cm^{-2})
0
0.1
0.2
0.3
0.4
0.5
0.6
Al-concentration x

FIG. 6

SURFACE TRAP DENSITY (cm^{-2})=2.7e12* (0.05*x*d*(nm))

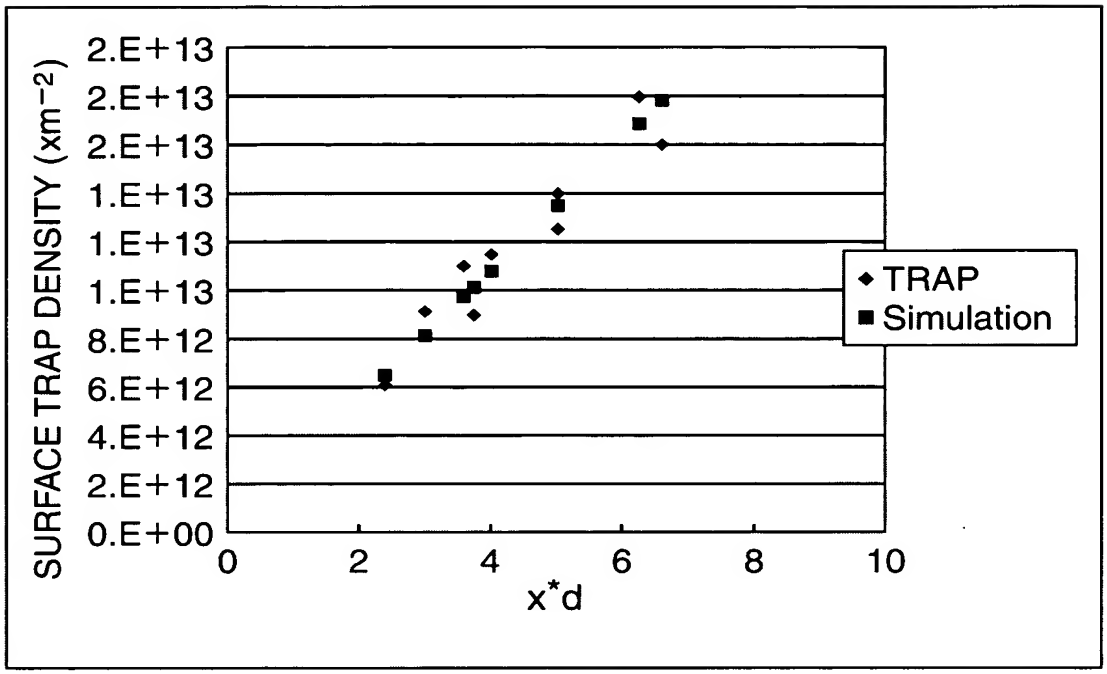


FIG. 7

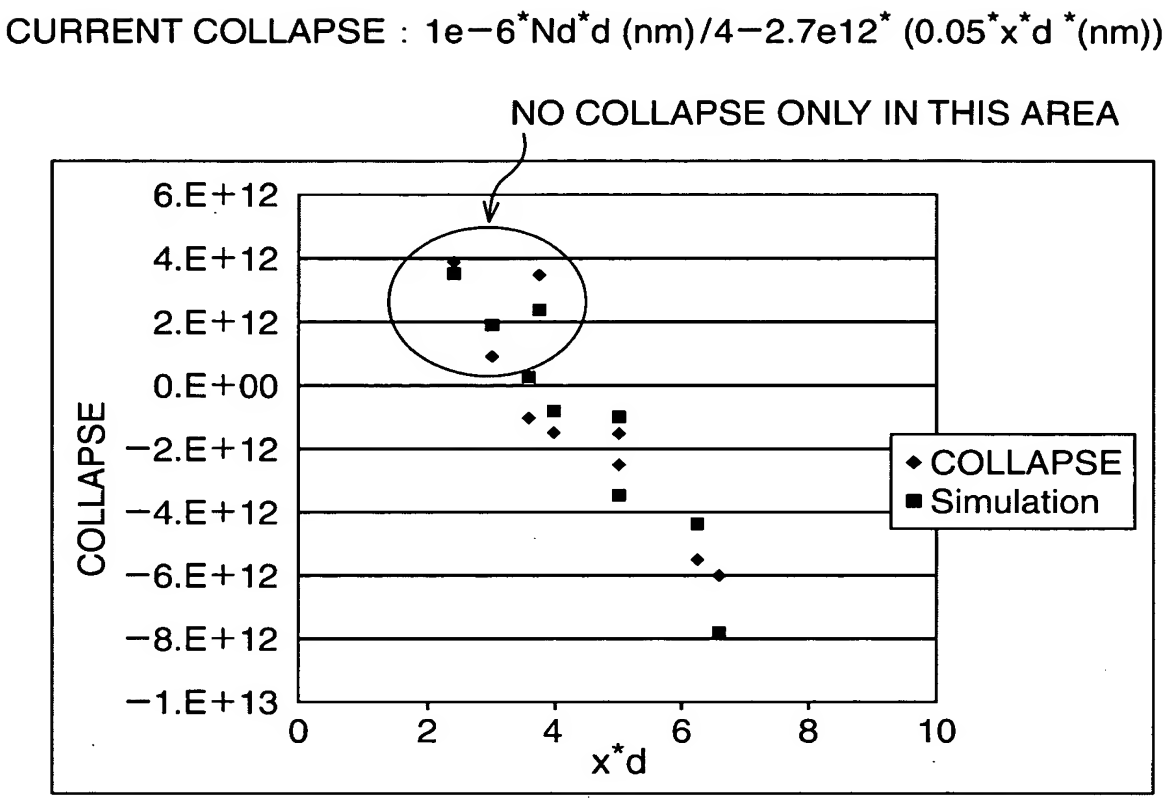

CURRENT COLLAPSE : 1e−6*Nd*d (nm)/4−2.7e12* (0.05*x*d *(nm))
NO COLLAPSE ONLY IN THIS AREA
6.E+12
4.E+12
2.E+12
0.E+00
−2.E+12
−4.E+12
−6.E+12
−8.E+12
−1.E+13
COLLAPSE
0
2
4
6
8
10
x*d
◆ COLLAPSE
■ Simulation

FIG. 8

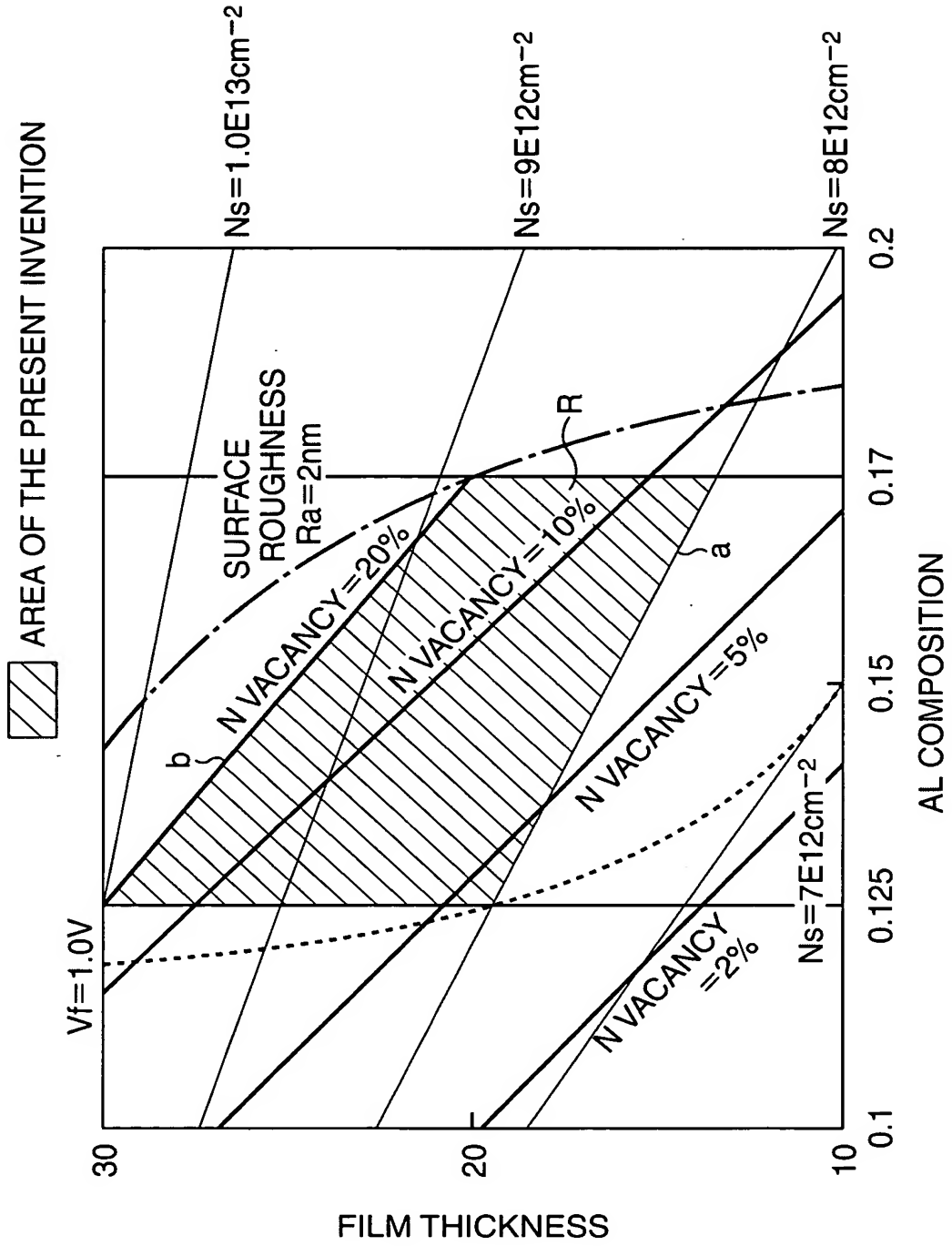

AREA OF THE PRESENT INVENTION
Ns=1.0E13cm^{-2}
Ns=9E12cm^{-2}
Ns=8E12cm^{-2}
SURFACE ROUGHNESS Ra=2nm
R
N VACANCY=20%
N VACANCY=10%
N VACANCY=5%
N VACANCY =2%
a
b
Vf=1.0V
Ns=7E12cm^{-2}
30
20
10
0.2
0.17
0.15
0.125
0.1
FILM THICKNESS
AL COMPOSITION

FIG. 9

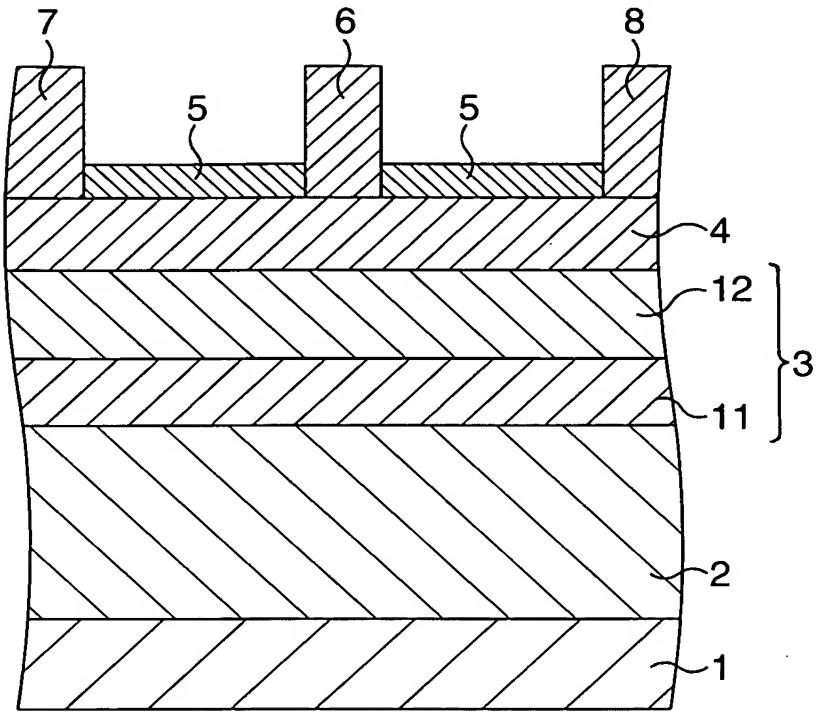
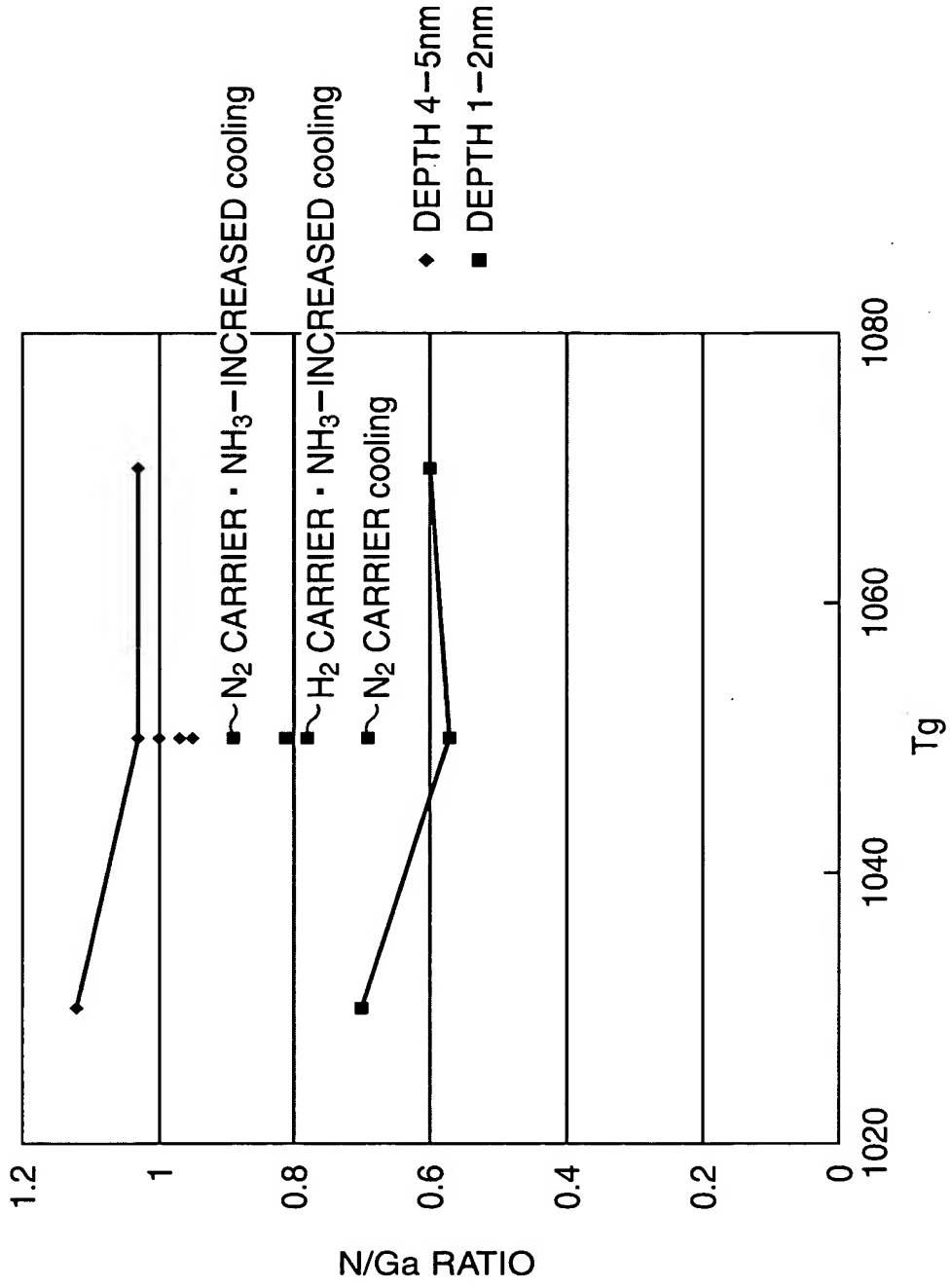


FIG. 10


DEPTH 4–5nm
DEPTH 1–2nm
N_2 CARRIER · NH_3–INCREASED cooling
H_2 CARRIER · NH_3–INCREASED cooling
N_2 CARRIER cooling
1.2
1
0.8
0.6
0.4
0.2
0
N/Ga RATIO
1020
1040
1060
1080
Tg

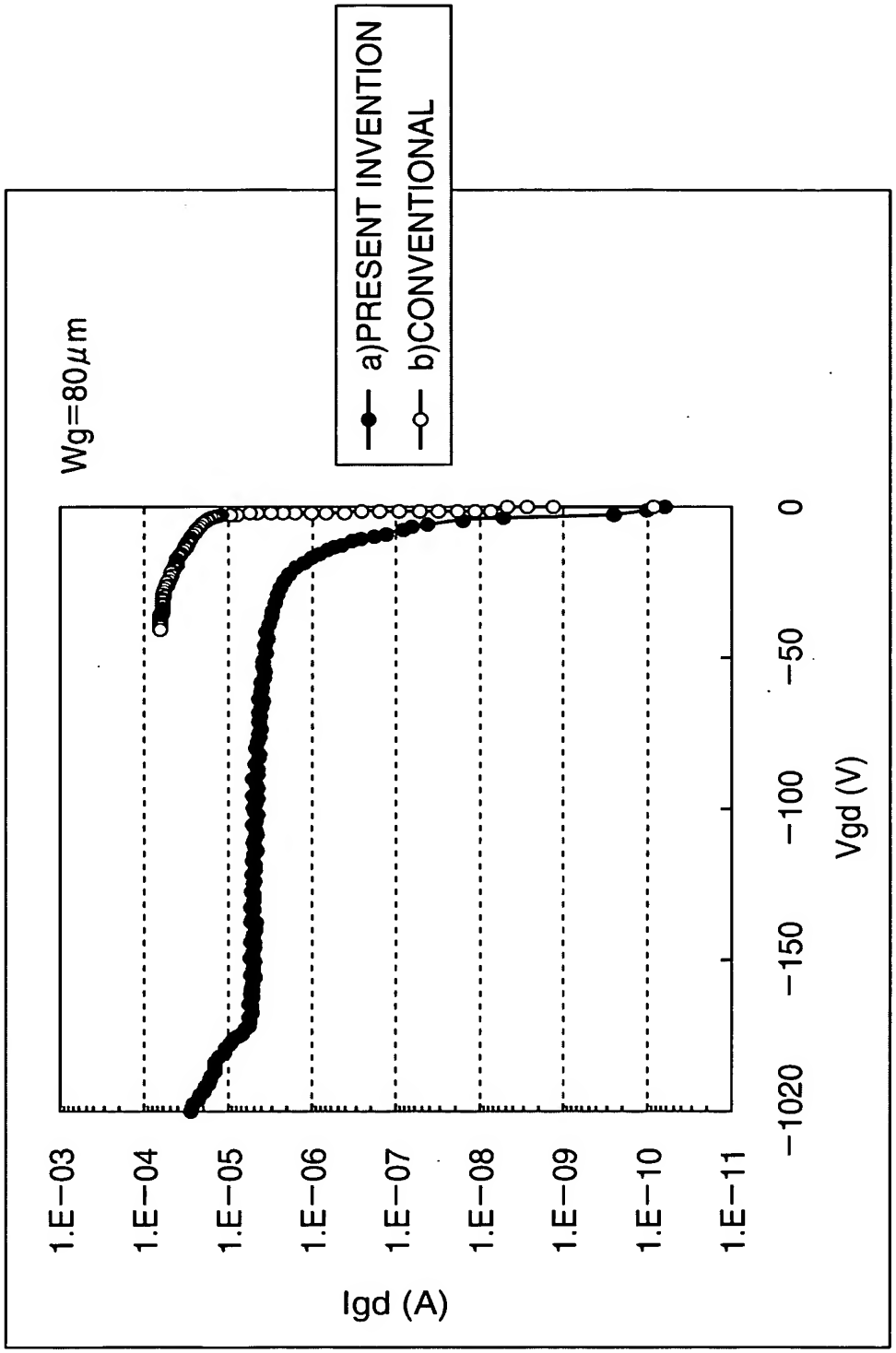


FIG. 11 Prior Art

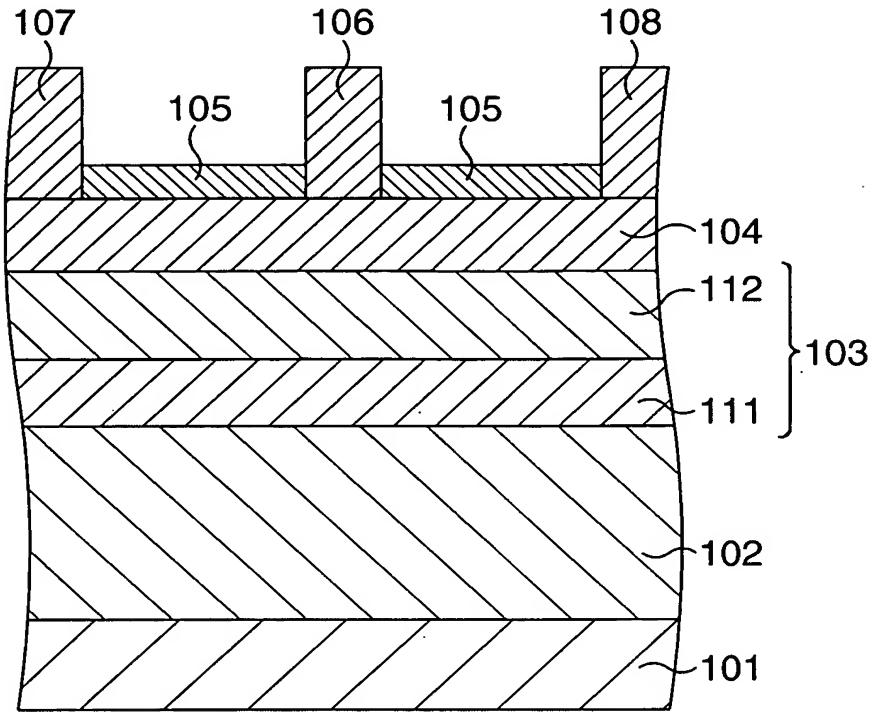



FIG. 12 Prior Art